information signal and for performing one of a reproducing operation and a recording operation on said discs; and

a system controlling means coupled to said signal processing means for controlling generation of the output signal of said signal processing means.

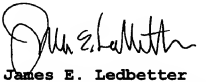
REMARKS

At the outset, the Applicants wish to thank the Examiner for the courtesy shown to them and their attorney during a personal interview on August 2, 2000. During this interview, the above amendments to the claims were discussed, with the exception of new claim 48.

In addition to the claim amendments, this Preliminary Amendment makes formal changes to the drawings and specification. The changes to Figs. 4A and 4B correspond to drawing changes in the parent reissue application and are supported by the originally filed specification of the present continuation reissue application which refers to respective focal distances FD and working distances WD" of Figs. 4A and 4B. The specification has been amended to correct typographical errors in the original patent.

Entry of the above amendments and early and favorable consideration of this application in the form of a Notice of Allowance are respectfully requested.

Respectfully submitted,



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2 is a plan view showing an arrangement of a main section of the embodiment FIGS. 3A and 3B are perspective views of cartridges of optical discs in the embodiment.

In FIGS. 1 to 3A and 3B, reference numeral 1 denotes a first or second optical disc. Thicknesses of disc substrates of both of the first and second optical discs are different. Reference numeral 2 denotes a cartridge which encloses the optical disc 1 and protects. The cartridge 1 is made of plastics or the like. Reference numeral 3 denotes a first optical head and 5 indicates a second optical head. Each of the optical heads is constructed by a converging optical [system] unit comprising: an objective lens; a semiconductor laser; a photo detector; a beam splitter; and the like (all of the above components are not shown). Each of the optical head detects an information signal, a focusing error signal, and a tracking error signal which have been recorded on the optical disc 1 on the basis of an intensity or an intensity distribution of the reflected lights of a laser beam irradiated onto the optical disc 1 and generates a photo detection signal to the outside. An information signal is recorded onto or erased from the optical disc 1 by modulating an intensity of the laser beam. Both of the optical heads have bases to hold the above optical devices and actuators. A reproduction information signal, a focusing error signal, and a tracking error signal which are generated from the photo detector of the first optical head 3 are expressed by S_1, F_1, and T_1, respectively. Similar signals which are generated from the photo detector of the second optical [disc] head 5 are also expressed by S_2, F_2, and T_2, respectively. Reference numeral 4 denotes a first linear motor which is arranged below the optical disc 1 and moves the first optical head 3 in the radial direction of the disc in parallel with the disc surface. Reference numeral 6 denotes a second linear motor which is arranged below the optical disc 1 so as to face the first linear motor 4 and moves the second optical head 5 in a manner similar to the first optical head 3.

As shown in FIG. 2, the second linear motor 6 is extended until the further outside of the outermost peripheral portion of the optical disc 1. Therefore, when the second optical head 5 moves to the outermost side, the optical head 5 is projected from the lower surface of the optical disc. Reference numeral 7 denotes a discrimination hole formed on the surface of the cartridge 2.

The cartridge in the embodiment will now be described with reference to FIGS. 3A and 3B. The discrimination hole 7 is closed in the case where the optical disc 1 enclosed in the cartridge is the first optical disc shown in FIG. 3A and is open in the case where it is the second optical disc shown in FIG. 3B. Reference numeral 23 denotes a slide shutter. Since the optical disc apparatus of the embodiment has two optical heads, two slide shutters are provided. When the cartridges are removed from the optical disc apparatus, the slide shutters are closed to protect the internal discs from dusts.

Reference numeral 8 denotes a light emitting diode (hereinafter, abbreviated to an LED) which is arranged so as to be located over the discrimination hole 7 when the cartridge 2 has been loaded into the optical disc apparatus of the embodiment. Reference numeral 9 denotes a photo diode arranged at a position so as to face the LED 8 through the cartridge 2. The photo diode 9 generates a detection signal to a system controller 22, which will be explained hereinlater. Reference numeral 10 denotes a first selector for selecting either one of the first group of photo detection signals (S_1, F_1,

signal in accordance with the signal F_2 and supplies to the actuator of the second optical head 5 through the third selector 14, thereby eliminating the focusing error. The linear motor control circuit 15 generates the driving current to the linear motor 6 in response to the control signal from the system controller 22, thereby moving the second optical head 5 in the inner or outer rim direction of the optical disc 1. The spindle control circuit 17 extracts a clock component from the information signal S_2 and controls the spindle motor 18, thereby rotating the optical disc 1 at a constant linear velocity (CLV) or a constant angular velocity (CAV) or the like. The signal processing circuit 19 executes signal processes such as demodulation, decoding, and the like to the information signal S_2 in the reproducing mode and generates to the outside as audio or video signals or the like. On the other hand, the signal processing circuit 19 executes signal processes such as encoding, modulation, and the like to the audio or video signals or the like which have been supplied from the outside in the recording mode and generates to the LD driving circuit 20 as a recording signal. Until the cartridge 2 is [loaded]. unloaded the second optical head 5 records or reproduces the information signal onto/from the second optical disc 1.

On the other hand, in the case where the cartridge 2 enclosing the first optical disc has been loaded into the optical disc apparatus of the embodiment, since the discrimination hole 7 is closed, the photo diode 9 doesn't detect the transmission light. Therefore, the system controller 22 determines that the disc in the cartridge 2 is the foregoing first optical disc. Thus, the controller 22 generates control signals to the first to fifth selectors 10, 12, 14, 16, and 21 so as to select the terminals A on the first optical head side. Therefore, the semiconductor laser of the first optical head 3 is selected as an output destination of the driving current which is supplied from the LD driving circuit 20. The photo detector of the first optical head 3 is selected as an input destination of the tracking control circuit 11, focusing control circuit 13, spindle control circuit 17, and signal processing circuit 19. The actuator of the first optical head 3 is selected as an output destination of the actuator driving signals of the tracking control circuit 11 and focusing control circuit 13. The first linear motor 4 is selected as an output destination of the driving current of the linear motor control circuit [17] 15.

Therefore, the first optical head 3 irradiates the laser beam and converges onto the information track on the optical disc 1 without an aberration. Simultaneously, the reflected lights from the disc are detected and generated as the information signal S_1, focusing error signal F_1, and tracking error signal T_1. The above signals are supplied through the first selectors 10 to the respective circuits That is, the signal S_1 is supplied to the spindle control circuit 17 and signal processing circuit 19. The signal F_1 is supplied to the focusing control circuit 13. The signal T_1 is supplied to the tracking error detecting circuit 11. The subsequent operations are similar to those in the case of the second optical disc mentioned above.

In the case where the objective lens of the second optical head is a lens of a high NA and a short [operating] working distance, it is necessary to set an interval between the second optical head 5 and the surface of the optical disc 1 to be fairly narrower than that in the case of the first optical head [5] 3.

Therefore, while the first optical disc is loaded, the controller 22 controls the second linear motor 6, thereby moving the second optical head 5 to

system mentioned in the second embodiment of the invention together with the first semiconductor laser 32, the first collimating lens 33, the first beam splitter 34, and the first mirror 35. The second objective lens 46 constructs the second converging optical system together with the first semiconductor laser 32, the first collimating lens 33, the first beam splitter 34, [and the] [first mirror 35] which are commonly used for the first converging optical system. The first converging optical system is mounted onto a common base (not shown) together with the first and second shutters [5] 51 and 52,

thereby constructing the fourth optical head 50. Since the lens holder 39 and the actuator 40 have the same construction as those in the third optical head 30 in the second embodiment, their descriptions are omitted here. The fourth optical head 50 is attached to the first linear motor 4.

The operation of the optical disc apparatus in the embodiment with the above construction will now be described hereinbelow. The kind of optical disc is detected in a manner similar to the above. When the system controller 22 determines that the disc in the loaded cartridge 2 is the second optical disc, the controller 22 generates control signals to the first and second shutters 51 and 52 of the fourth optical head 50. When the control signals are supplied, the first shutter 51 is closed and the second shutter 52 is open. In the above state, the laser beam emitted from the first semiconductor laser 32 is converted into the parallel beam by the first collimating lens 33 and is divided into the transmission light and the reflected light by the first beam splitter 34. The transmission light is shut out by the first shutter 51 via the first mirror 35. Consequently, only the reflected light passes through the second shutter 52 and is converged onto the optical disc 1 by the second objective lens 46. The light reflected by the optical disc 1 is again converted into the parallel light by the second objective lens 46 and passes through the second shutter 52 and is reflected and separated by the first beam splitter 34 and is converged onto the first photo detector 38 by the first detecting lens 37. The first photo detector 38 generates the focusing error signal and tracking error signal from the converged reflected light of the disc and reproduces the information signal on the disc. The above operations are executed until the cartridge 2 is unloaded.

Since the operations of the first linear motor 4, tracking control circuit 11, focusing control circuit 13, linear motor control circuit 15, spindle control circuit 17, spindle motor 18, signal processing circuit 19, LD driving circuit 20, and system controller 22 are the same as those in the optical disc apparatus of the foregoing first embodiment, their descriptions are omitted here.

On the other hand, if the system controller 22 determines that the disc in the loaded cartridge 2 is the first optical disc, the first shutter 51 is opened and the second shutter 52 is closed. In the above state, in the transmission light and the reflected light by the first beam splitter 34, the reflected light is shut out by the second shutter 52 and only the transmission light passes through the first shutter 51 and is converged onto the optical disc 1 by the first objective lens 36. The other operations are executed in a manner similar to those in the case of the second optical disc.

As mentioned above, according to the third embodiment, in addition to the effects by the second embodiment, since the first and second shutters 51 and 52 are provided as light flux selecting means, the semiconductor laser, collimating lens, beam splitter, detecting lens,

and photo detector in each of the converging optical system can be commonly used and the size and weight of the optical head can be reduced. Therefore, assuming that a driving force of the linear motor is the same, the improvement of the performance such as reduction of the seeking time and the like can be realized.

FIGS. 9A and 9B show a detailed constructional diagram of an optical head of an optical disc apparatus in the fourth embodiment of the invention. In FIG. 9A, since the optical disc 1, first semiconductor laser 32, first collimating lens 33, first beam splitter 34, second objective lens 46, first detecting lens 37, and first photo detector 38 are constructed in a manner similar to those in the foregoing fourth optical head 50, their descriptions are omitted here. Reference numeral 56 denotes a lens holder to hold the second objective lens 46; 57 an actuator to which the lens holder 56 is attached; 54 a wave front correcting lens attached to a slider 55, which will be explained hereinlater, so that the optical axis is in parallel with the optical axis of the second objective lens 46; and 55 the slider which supports the wave front correcting lens 54 and is arranged so as to transverse in the plane which is perpendicular to the light flux between the first beam splitter 34 and the second objective lens 46, thereby enabling the wave front correcting lens 54 to be moved in such a plane. Moreover, such a movable range is set to a position (shown by P_1 in the diagram) where the wave front correcting lens 54 is perfectly deviated out of the light flux or a position (shown by P_2 in the diagram) where the optical axis of the[slider 55] wavefront correcting lens 54 coincides with the optical axis of the second objective lens 46. The above-mentioned component elements are attached to a base (not shown) and construct a fifth optical head 53.

FIG. 9B is a plan view when the wave front correcting lens 54 and the slider 55 are seen from the direction of the optical axis. In the diagram, the lens 54 is movable in the directions shown by arrows. The wave front correcting lens 54 has been designed in a manner such that a synthetic optical system with the second objective lens 46 is identical to the foregoing first objective lens. That is, the lens 54 has been designed so as to correct the aberration by the disc substrate of the first optical disc. In the fifth optical head 53, the second objective lens 46 constructs the second converging optical system mentioned in the second embodiment of the invention together with the first semiconductor laser 32, first collimating lens 33, and first beam splitter 34 and can be also regarded such that they construct the first converging optical system by adding the wave front correcting lens 54 to the second converging optical system.

Since a whole construction of the optical disc apparatus in the fourth embodiment is substantially the same as that of the optical disc apparatus of the third embodiment shown in FIG. 7 mentioned above, its description is omitted here.

The operation of the optical disc apparatus in the fourth embodiment with the above construction will now be described hereinbelow with respect to only the fifth optical head 53. The kind of optical disc is detected in a manner similar to the above. If the system controller 22 determines that the disc in the loaded cartridge 2 is the second optical disc, the controller 22 generates a control signal to the slider 55. When the control signal is supplied, the slider 55 moves the wave front correcting lens 54 to the position P_1. The laser beam emitted from the first semiconductor laser 32 is converted into

optical system corresponding to the thin disc substrate, a tracking error signal cannot be ordinarily obtained from an optical disc of a thick disc substrate due to a spherical aberration of the converging beam. Consequently, two optical discs having different thicknesses can be discriminated by checking the presence or absence of the tracking error signal. In such a case, there is an excellent effect such that the apparatus is simplified because there is no need to use the detecting means such as LED and photo diode and the like

The optical head in each of the above-described optical disc apparatuses has been constructed by a conventional optical system using the objective lens made of a quartz glass or the like. An optical head in each of optical disc apparatuses of embodiments, which will be explained hereinlater, differs from the above optical head and is constructed by forming an optical system onto a thin film waveguide.

FIG. 10 is a block diagram showing a construction of an optical disc apparatus according to the fifth embodiment of the invention. Further, FIG. 11 is a schematic perspective view showing a construction of an optical head of the optical disc apparatus in the fifth embodiment of the invention. Since a construction shown in FIG. 10 is substantially the same as that of the optical disc apparatus in the second embodiment of the invention shown in FIG. 5 except that a sixth optical head 60 is used, its description is omitted here. The sixth optical head 60 shown in FIG. 11 will now be described in detail hereinbelow.

In FIG. 11, reference numeral 1 denotes the same optical disc as that described in the foregoing embodiments. Reference numeral 200 denotes an information track formed on the optical disc 1. Reference numeral 61 denotes a substrate formed by $LiNbO_3$ or the like. The substrate 61 is attached to a head base through a focusing actuator and a tracking actuator and constructs the sixth optical head 60 together with them. Since the focusing actuator, tracking actuator, and head base which have conventionally been well known can be used as those components, their detailed description and the drawings are omitted here. Reference numeral 62 denotes an optical waveguide formed on the substrate [51] 61

by Ti diffusion or the like; 63 a first semiconductor laser coupled to an edge surface of the optical waveguide 62; and 64 a first waveguide lens arranged on an optical path of the waveguide light which has been emitted from the first semiconductor laser 63 and entered the optical waveguide [61] 62.

For instance, a Fresnel lens formed by an electron beam lithography can be used as a lens 64. Reference numeral 65 denotes a first converging grating coupler formed on the optical path of the parallel waveguide light. The coupler 65 emits the waveguide light to a position out of the optical waveguide 62 and converges onto the optical disc 1. The first converging grating coupler 65 is a grating having a chirp (irregular period) by a curve formed on the waveguide by electron beam direct drawing or the like. Reference numeral 66 denotes a first beam splitter which is arranged between the first waveguide lens 64 and the first converging grating coupler 65 and separates the waveguide light which has been returned into the optical waveguide 62 through the first converging grating coupler 65 after it had been reflected by the optical disc 1. Reference numeral 67 denotes a first waveguide converging lens which is arranged on the optical path of the return waveguide light which has been separated by the first beam splitter 66 and con-

verges the return light. Reference numeral 68 denotes a first photo detector which is coupled to the side surface of the optical waveguide 62 and detects the return waveguide light which has been converged by the first waveguide converging lens 67.

Similarly, reference numeral 69 denotes a second semiconductor laser coupled to the edge surface of the optical waveguide 62; 70 a second waveguide lens arranged on the optical path of the waveguide light which has been emitted from the second semiconductor laser 69 and entered the optical waveguide [61] 62;

and 71 a second converging grating coupler formed on the optical path of the parallel waveguide light. The coupler 71 emits the waveguide light to a position out of the optical waveguide 62 and converges onto the optical disc 1. Reference numeral 72 denotes a second beam splitter which is arranged between the second waveguide lens 70 and the second converging grating coupler 71 and separates the waveguide light which has been returned into the optical waveguide 62 through the second converging grating coupler 71 after it had been reflected by the optical disc 1. Reference numeral 73 denotes a second waveguide converging lens which is arranged on the optical path of the return waveguide light which has been separated by the second beam splitter 72 and converges the return waveguide light. Reference numeral 74 denotes a second photo detector which is coupled to the side surface of the optical waveguide 62 and detects the return waveguide light converged by the second waveguide converging lens 73.

A curve chirp grating of the first converging grating coupler 65 has been designed in a manner such that, for instance, NA =0.45 and the emission light can be converged until a diffraction limit and the aberration due to the disc substrate of the thickness d_1 can be corrected. The second converging grating coupler 71 has been designed in a manner such that, for example, NA =0.3 and the aberration due to the disc substrate of the thickness d_2 can be corrected.

The first and second beam splitters 66 and 72 are attached at positions which are deviated so that the reflected light of each beam splitter does not enter the other beam splitter as a stray light.

Such an optical waveguide and a waveguide type device have been described in detail in, for example, Nishihara, Haruna, and Saihara, "Optical Integrated Circuit", Ohm Co., Ltd., 1985, or the like. In the invention, both of the above well-known optical waveguide and waveguide type device can be used in the optical waveguide 62 or the like.

The operation of the optical head in the fifth embodiment with the above construction will now be described hereinbelow.

If the optical disc 1 is the first optical disc, the driving current is supplied to the first semiconductor laser 63. Then, the laser 63 emits a laser beam from one edge surface of the optical waveguide 62. The laser beam propagates as a waveguide light. The waveguide light is converted into the parallel light by the first waveguide lens 64. The parallel light transmits the first beam splitter 66 and subsequently enters the first converging grating coupler 65. The coupler 65 extracts the parallel light out of the optical waveguide 62 and converges onto the information track 200 on the first optical disc 1. The reflected light from the disc surface again enters the optical waveguide 62 through the first converging grating coupler 65 and propagates as a return waveguide light in the opposite direction. Further, the return